# SACCHARINE:

## The New Sweet Product from Coal-Tar.

300 TIMES THE SWEETENING POWER OF CANE SUGAR.

A POWERFUL ANTISEPTIC.

ABSOLUTELY NON-FERMENTING.

POSITIVELY HARMLESS TO THE HUMAN SYSTEM.

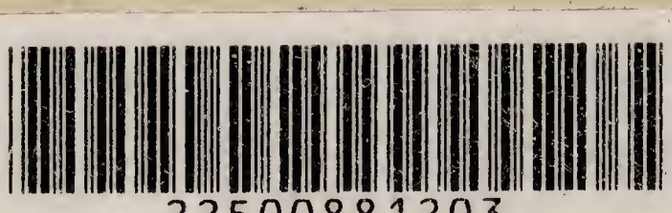
*Sole Agents for Great Britain, Spain, and Portugal:*

WILSON, SALAMON & Co.,

18, Billiter Street,

London, E.C.

1887.



# SACCHARINE.

## THE NEW SWEET PRODUCT FROM COAL-TAR.

THE conversion of saccharine, the sweet derivative of coal-tar from a laboratory curiosity into a commercial product has at length been achieved, and the details of its manufacture have been brought so completely under control, that its formation in quantity sufficient to meet the requirements of every market has now become a matter of certainty.

Without the technical knowledge of an expert, it would be impossible adequately to estimate the difficulties which have had to be surmounted in order so to control the conditions of the requisite chemical reactions as to ensure the regularity of their fulfilment upon the large scale. It would be considered no ordinary achievement in mineral chemistry to perfect a manufacturing process in which the final product was the result of seven successive complicated combinations. How much greater the task of building up an organic substance in which the contained molecules must not only be constant in composition, but in which the atoms constituting the molecule must always occupy the same position relatively to one another. The latter phase of the problem has constituted the chief triumph of the discoverer, Dr. Fahlberg, and has allowed of his saccharine being yielded in quantities very nearly approaching that dictated by theory.

Eight years of incessant work and unflinching resolution have been required in order successfully to battle with the subtleties of the problem. Public curiosity has been aroused by the announcement of the discovery of saccharine, its probable applications in medicine and the arts, and the promise of its speedy preparation

upon the large scale. The eagerness with which its introduction has been anticipated was made sufficiently manifest during the long interval which separated its discovery from its manufacture.

Fortunately there will now be no reason to regret this delay, for it has allowed of experiments being conducted, with quantities of saccharine produced upon the laboratory scale, which have not only marked out a clear future for this remarkable substance, but which have in addition indicated its properties in a manner which must prove of the utmost value to those who may now desire to avail themselves of its use.

Saccharine will be employed in food preparations and in pharmacy. It is therefore a matter of prime importance that its therapeutic and its physiological properties should already have been exhaustively studied by men whose world-wide reputations constitute a guarantee for the accuracy and thoroughness of their work. And it is still more satisfactory to find that they one and all declare it to be absolutely innocuous to the human system, and well calculated to fulfil the most sanguine predictions of its discoverer. In this way captious criticism has been disarmed, and saccharine is now in a position to be tested upon its merits.*

It has this in common with many great discoveries: it was the result of an accident. Dr. Fahlberg, whilst in America, had associated himself with the chemical investigation of coal-tar derivatives, and was attacking the subject from a purely theoretical and philosophical standpoint. His researches were directed to the class of bodies known as the sulphamides of toluol; and it was during the study of the oxidation products of these compounds that he chanced upon

---

* *For full references to researches in connection with use of saccharine, see—*

1.—*Gazetta della Cliniche di Torino*, 1886. *Nos.* 14 *and* 15.

2.—*Archivio per le Scienze Mediche. Vol. IX. No.* 22, *p.* 415.

3.—*Archives Italiennes de Biologie*, 1886. *Vol. VII. pp.* 158—175.

4.—*Berichte in der Deutschen Zuckerindustrie von Herbertz. Berlin*, 1886. *Jahrgang IX. No.* 24.

5.—*A. Stutzer. Ueber Fahlberg's Saccharin. Centralblatt f. d. Med. Wissench.*, 1886. *No.* 4.

6.—*E. Salkowsky. Ueber das Verhalten das, sogenn Saccharin m Organismus. Virchow's Archiv für Pathologische Anatomie und Physiologie und für Klinische Medicin.* 105 *Band. p.* 46. *Berlin*, 1886.

7.—*E. Stadelman. Mittheilungen aus der Medicinischen Klinik der Grossherzogl. Universität, Heidelberg*, 1886.

8.—*Sir Henry Roscoe. Royal Institution Lecture. April*, 1886.

one which immediately attracted his attention by its intensely sweet taste. To this substance he gave the name of "Saccharine," and it has since been described by Sir Henry Roscoe, in his lecture at the Royal Institution, as "the most remarkable of all the marvellous products of the coal-tar industry."

Toluene is obtained in the destructive distillation of coal, as employed in the manufacture of gas, and may also be derived from several oils and bituminous residues. It is a derivative of coal-tar, and as such is forthcoming in far greater quantity than can ever be demanded by Dr. Fahlberg and his colleagues. An ample supply of the base from which saccharine is prepared is therefore at all times secure.

It may be of interest briefly to indicate the various processes to which toluene is subjected before it finally emerges as saccharine.

1.—Toluene is heated with ordinary sulphuric acid of 168° Twaddel, at a temperature not exceeding 100° C. This effects the formation of toluene sulphonic acid.

$$C_6H_5CH_3 + H_2SO_4 = C_6H_4\begin{cases} CH_3 \\ SO_2{\cdot}OH \end{cases} + H_2O$$

Toluene. Toluene Sulphonic Acid.

2.—The sulphonic acid produced consists of two modifications —the ortho and the para acids. The excess of sulphuric acid is neutralized by chalk, and the two sulphonic acids are converted into the corresponding calcium salts.

$$2\left(C_6H_4\begin{cases} CH_3 \\ SO_2OH \end{cases}\right) + H_2SO_4 + 2CaCO_3 = \left(C_6H_4\begin{cases} CH_3 \\ SO_3 \end{cases}\right)_2 Ca +$$

Calcium Toluene Sulphonates

$$CaSO_4 + 2CO_2 + 2H_2O$$

3.—The calcium salts are now treated with carbonate of sodium to obtain the sodium salts with precipitation of carbonate of calcium.

$$\left(C_6H_4\begin{cases} CH_3 \\ SO_3 \end{cases}\right)_2 Ca + Na_2CO_3 = 2C_6H_4\begin{cases} CH_3 \\ SO_2{\cdot}ONa \end{cases} + CaCO_3$$

Sodium Toluene Sulphonates.

4.—The sodium sulphonates in solution are evaporated, and are subsequently solidified and dried.

5.—The sodium sulphonates are now converted into their corresponding sulphonic chlorides by intimately mixing them with phosphorus trichloride, and then passing a current of chlorine over the mixture.

$$C_6H_4\begin{cases}CH_3\\SO_2\cdot ONa\end{cases} + (Pcl_3 + 2Cl) = C_6H_4\begin{cases}CH_3\\SO_2\cdot Cl\end{cases} + POCl_3 + NaCl$$

Toluene Sulphonic Chlorides.

The two sulphonic chlorides—the ortho and the para—are now separated by crystallization, the ortho compound only being able to yield saccharine directly.

6.—The ortho-toluene sulphonic chloride is next converted into the ortho-toluene sulphonic amide by treatment with ammonium carbonate :—

$$C_6H_4\begin{cases}CH_3\\SO_2Cl\end{cases} + (NH_4)_2\,CO_3 = C_6H_4\begin{cases}CH_3\\SO_2\cdot NH_2\end{cases} + NH_4Cl + H_2O + CO_2$$

Toluene Sulphonic Chloride.

Toluene Sulphonic Amide.

7.—The ortho-toluene sulphonic amide is now oxidized, preferably by means of potassic permanganate in presence of an alkali :—

$$C_6H_4\begin{cases}CH_3\\SO_2.NH_2\end{cases} + 3O + NaHO = C_6H_4\begin{cases}CO.ONa\\SO_2.NH_2\end{cases} + 2H_2O$$

Toluene Sulphonic Amide.

Sodium Ortho-Toluene Sulphamido-Benzoate.

This latter product is precipitated with dilute mineral acid, when benzoyl sulphonic imide, or saccharine, at once separates out :—

$$C_6H_4\begin{cases}CO.ONa\\SO_2\cdot NH_2\end{cases} + HCl = NaCl + H_2O + C_6H_4\begin{cases}CO\\SO_2\end{cases}NH$$

Saccharine.

Benzoyl sulphonic imide, or "saccharine," as produced upon the large scale, is a white amorphous powder, and when subjected to

microscopic examination is seen to possess a distinct crystalline character.

It is intensely sweet, *and if tasted in its pure state the delicacy of its flavour is obscured*, because, as the discoverer recently stated at the meeting of the British Association at Manchester, the intensity of sweet produces so acute an action upon the nerves of the tongue, that it tends to deaden their sensibility, just as too powerful a source of light will obscure rather than foster the power of vision. Indeed, saccharine should be regarded in the light of an essence, which requires diluting or embodying with other materials before its true value as a flavouring material can be made apparent. It is in this respect analogous to vanillin, another recently-discovered derivative of coal-tar, which is now rapidly superseding the natural vanilla as a flavouring material; and it is important to notice that the commercial success of this product appeared at one time to be in jeopardy, because it was employed in its pure and intense form, rather than in a sufficiently-diluted form of solution. It cannot, therefore, be too strongly urged that saccharine should not be tasted in the pure dry state with a view to institute comparisons, or judge of its adaptability for various purposes.

Hence, it becomes of importance to find solvent media for saccharine, and fortunately these are conveniently to hand. In cold water it is but slightly soluble, in warm water somewhat more, and in boiling water it is sufficiently soluble for many practical purposes. The solubility of saccharine is greatly increased by neutralizing the fluid in which solution is effected; and, in many cases, convenient preparations may be effected with the aid of carbonate of soda or potash. When saccharine is introduced into a fluid containing more carbonates, carbonic acid gas is evolved, and the soda or potash salts of saccharine are formed. The latter taste almost equally sweet with saccharine, so that the alkaline carbonates form a very good medium for mixing with saccharine in the form of powder, with a view to ensure the solution of the latter when it is introduced into any required fluid.

Alcohol furnishes another good solvent for saccharine, and will probably be largely employed in connection with the use of saccharine

as an antiseptic sweet for wines, liqueurs, cordials, essences, &c. Its solubility in alcohol has been carefully determined by Mosso as follows :—

| One gallon of— | Dissolves of saccharine— |
|---|---|
| 10% alcohol ... ... ... | 378·7 grains. |
| 20% „ ... ... ... | 517·3 „ |
| 30% „ ... ... ... | 802·9 „ |
| 40% „ ... ... ... | 1391·6 „ |
| 50% „ ... ... ... | 1934·1 „ |
| 60% „ ... ... ... | 2023·0 „ |
| 70% „ ... ... ... | 2149·0 „ |
| 80% „ ... ... ... | 2250·5 „ |
| 90% „ ... ... ... | 2184·0 „ |
| Absolute „ ... ... ... | 2118·9 „ |

It will be noticed that 80% solutions give the maximum of solvent efficiency. The numbers stated above hold true for normal temperatures; but it will be found more convenient in practice to dissolve saccharine in warm solutions of alcohol, care, of course, being taken to prevent volatilization.

It is also freely soluble in warm glycerine.

Saccharine fuses at a temperature of about 200° C., and then undergoes partial decomposition, and gives off a readily recognizable odour, which may often assist in its identification for analytical purposes. It has often been stated that a taste of bitter almonds attaches to saccharine and its solutions; but, inasmuch as these observations were made upon those samples prepared in the laboratory, it may be well to emphasize the fact that such taste has been proved to be due to harmless impurity, which has now been wholly removed. Indeed, it will be found that the manufactured product is superior to the laboratory samples, not only in sweetening power, but also in general purity.

Experiments conducted upon the sweetening power of saccharine, as first prepared in the laboratory, revealed the fact that it was 280 times sweeter than ordinary cane sugar; but the pure product now placed upon the market is fully 300 times sweeter than cane sugar.

Professor Stutzer, of Bonn, has stated that it is quite possible to detect the sweet taste of saccharine, when one part by weight is dissolved in 70,000 parts by weight of pure distilled water.

The composition of saccharine shows that it belongs to the class of bodies known to chemists as the aromatic derivatives, and is essentially different in constitution to sugars which are members of the family recognized by chemists as the carbohydrates. The proof that saccharine is not a carbohydrate is at once forthcoming in an inspection of its constitutional formula, which is as follows :—

$$C_6H_4 \begin{cases} CO \\ SO_2 \end{cases} NH.$$

Now it is difficult adequately to estimate the commercial advantages arising out of this fact. It is well known, and fully substantiated, that the organisms which are capable of effecting fermentation in a fluid require carbohydrate food in order to thrive and multiply. They have the power of decomposing or degrading the carbohydrate, and of obtaining from it the essentials of their existence. Sugar being a carbohydrate is, therefore, liable to undergo fermentation when in solution and in presence of certain organisms which abound almost everywhere. Various sugars are, indeed, used industrially as food for these organisms by brewers, distillers, vinegar makers, &c.; but it is also found that sugar solutions are, for the same reason, liable to undergo decomposition in preparations where fermentation means absolute destruction of their commercial value. This is true, for instance, of preparations of syrups, preserves, wines, cyder, pharmaceutical mixtures containing sugars, such as phosphate food, and many other compounds too numerous to mention.

The constitution of saccharine is in itself sufficient to negative the possibility of any such fermentation arising from its use, and hence it affords the means of imparting a sweet flavour, which can be increased at discretion without undue addition of weight and bulk, with the certainty that it will not detrimentally affect the substance into which it has been introduced.

But the employment of saccharine in this direction is attended

with advantages of even greater importance. They are due to the marked antiseptic properties of saccharine, qualities which might almost have been predicted for it, seeing its close chemical connection with the phenol compounds. A series of most careful and accurate experiments upon the antiseptic properties of saccharine have been carried out by Aducco and Mosso, and subsequently by Stutzer and Stadelman, all proving conclusively that it possesses marked powers in this direction, and that it is almost as energetic in its action as salicylic acid and thymol. It can, moreover, be applied where it would be impracticable to use the latter bodies. It has, moreover, been shown to exert a strongly retarding influence upon alkaline fermentation of urine, an observation which is not likely to be lost sight of by medical men.

The physiological researches relating to saccharine have been of a most searching and complete character, and have embraced a study of its action upon various species, including the frog, the dog, and the human being. In all cases the result has been the same. No matter where or how administered it has passed unchanged with amazing rapidity into the bladder. The urine has always tasted sweet some little time after saccharine has been administered, and within 24 hours it has entirely disappeared from the system, without leaving the slightest signs of its presence, even when seventy-five grains doses were given daily. It has, moreover, been proved to be without action upon ptyalin, diastaste, or the digestive functions of the system. It is not absorbed by, nor is its presence discernible in, human milk, and even when injected under the skin or directly into the intestines, the result is the same. It is rapidly absorbed, and within half-an-hour may be found unchanged in the urine. The latter is, moreover, unaffected with respect to its gravity and components, even in cases where the slightest variation in diet would immediately and injuriously affect the urinary system.

From this it will be apparent that saccharine cannot usurp the functions of a food. From the medical man's point of view it must rather be regarded as a condiment or flavouring, which may advantageously replace sugar in all cases where the latter is contra-indicated. It will be employed with benefit in the treatment of

the following affections, in which cane sugar is either absolutely interdicted or its use extremely limited :—

1.—In all cases of true diabetes mellitus and of glycosurea.

2.—In the various cases of Bright's disease, and in renal disorders which may probably have their origin in inefficient action or morbid state of the liver.

3.—In most, if not all, forms of a marked gouty diathesis.

4.—In all cases of hepatic enlargement, attended by periodic or chronic congestion, due to sojourn in tropical climes; and with imperfect or impaired digestion due to torpid liver. In chronic dyspepsia, and in those dyspeptic states attended by derangement of the gastric secretion.

5.—In senile affections, in which various bladder and genito-urinary disorders occur. In those cases especially are found those cystitic complications where ordinary sugar food is most objectionable, and where, indeed, its use has to be greatly restricted.

6.—In general obesity, and in those cases in which fat is prone to be abnormally developed in the internal organs.

7.—In many of the affections of children, attended by impaired digestion, and hepatic enlargement, and in chronic glandular diseases of children.

In describing Saccharine for use in pharmaceutical preparations, it will be well, invariably, to describe it as "Fahlberg's Saccharine."

It will be seen how wide a scope is given for the exercise of ingenuity in the preparations of dietetic articles containing saccharine, and more especially in connection with its embodiment in harmless media. It may be mentioned that mannite, which has been proved to be without injurious action upon diabetic patients, and milk sugar, have already been largely employed in this direction.

It is a matter of common experience that substances which do not exert an immediate tonic effect are injurious to the system after they have been administered during extended periods of time. Saccharine has been subjected to, and has satisfactorily withstood, this crucial test; and Professor Dr. Leyden, Privy Counsellor Physician (Geh. Med. Rath) of the "I. Medicinischen Universitätsklinik der Königl. Charité zu Berlin," has given a formal certificate, of which

the following is a translation, respecting his experience of the use of saccharine as an article of diet :—

"Since February of this year, Fahlberg's saccharine, obtained from the firm of Fahlberg & List of Leipzig (now of Salbke-Westerhüsen), has been directly administered in this hospital to a great number of patients, convalescents, and healthy individuals. It was further incorporated as a relish for sweetening foods and beverages, and tested in order to see whether its taste could be differentiated in individual cases, how it would act upon the system, and whether evils or advantages accompanied its employment. At the same time it was given to diabetic patients, and its therapeutic effects noted. As the result of these experiments and this experience, Messrs. Fahlberg, List & Co., are hereby informed, in answer to their enquiry, that Fahlberg's saccharine agrees both with invalids and healthy individuals, that no anxiety as to its effect upon health need attend its use, and that saccharine may be consumed over prolonged periods. Some of our patients have taken it regularly during five months, without its exerting the slightest injurious action upon the human system. The use of saccharine allows of a much-needed enrichment of the diet of diabetic patients, inasmuch as they may now enjoy a sweet flavouring in diabetic bread and cakes, food, tea, coffee, soup and other nutriment, without the introduction of carbohydrates (sugar) into the system. These applications of saccharine were made in a neutral carbonate of soda solution; and also in the very practical and suitable form of tablets, containing five centigrammes of Fahlberg's saccharine and two centigrammes of carbonate of soda. The daily quantity which appeared to suit the taste of ordinary patients avaraged 0·15 grammes to 0·2 grammes of saccharine;* half to one-and-a-half grain of saccharine suitably embodied will be found ample to sweeten a cup of tea or coffee; larger quantities were, however, taken without derangement or injurious results of any kind whatever." "Berlin, 15th July, 1886."

---

**Saccharine has been given in daily quantity of 75 grains. This is more than will be required in practice. From half to one-and-a-half grain will sweeten a cup of tea or coffee according to taste.*

These statements have been freely endorsed by Dr. Stadelman, of Heidelberg University, Professor Salkowsky, of the Pathological Institute at Berlin, Professor Stutzer, of Bonn, and other savants. Saccharine has, moreover, been officially recognized as an approved article of diet by the German Government, large contracts having already been entered into for the supply of saccharine tablets for use in the army. The advantage resulting from the employment of the latter will be immediately apparent when it is stated that lozenges containing saccharine are prepared no larger in size than an ordinary acid drop; that one of them amply suffices to sweeten a cup of tea or coffee, and that a soldier can carry in his kit enough saccharine for a week's supply, in a bottle, the weight of which is scarcely appreciable.

A very wide field for the application of saccharine exists in the production of sweetmeats, preserves, and confectionery, which shall not, owing to the contained cane sugar, "create acidity." It is now possible to manufacture sweetmeats which can be freely given to delicate children without fear of digestive complications; it being generally conceded that it is owing to the large amount of sugar with which sweets are necessarily loaded that their injurious results are due when consumed in any but small quantity at a time. Manufacturers will find that they possess in this application ample scope for the production of specialties dependent upon the medium with which saccharine is incorporated. The same remark obviously holds good for preparations of infants' foods, rusks, diatetic biscuits, condensed milk, &c.

It is not suggested that saccharine shall be exploited as a competing product with cane sugar. To some extent it will necessarily displace it; but, it is anticipated, that the properties of saccharine will suffice to ensure its widespread application without the necessity of entering into a war of rates with sugar merchants. Especially is this the case with the preparation of jams, preserved fruits, and essences. It is found in practice that 1000 parts of glucose boiled—preferably in a vacuum pan—with one to two parts by weight of saccharine, produces a syrup which it is impossible to distinguish from the prepared syrup of the jam matter; but, with

these most important exceptions, that there is no crystallization, no scum produced upon the jam, and, consequently, no waste in the process of preparation; no absolute necessity to boil down the fruit, which can be preserved whole, with consequent retention of unimpaired flavour; and no chance of the development of mould or fermentation, owing to the antiseptic properties of saccharine and the absence of cane sugar.

The intensely sweet taste of saccharine and the manner in which it lingers on the palate, when mixed in relatively large quantity, renders it particularly valuable in disguising the taste of bitter and nauseous preparations, such as gentian, quassia, &c. With the alkaloids, such as quinine, morphine, codein, strychnine, &c., it forms salts which are remarkable for their absence of stringency, whilst the therapeutic powers of the alkaloids remain unchanged. It will be largely used in powders, both to disguise taste and in view of its preservative properties. It will, for instance, protect pepsin from fermentation, and it has been fully proved not to influence its digestive functions. It emphasizes the delicate flavour of mouth-washes containing myrrh and kindred substances, and constitutes with them a preparation of remarkable elegance and freshness.

It is impossible, within the limits of this pamphlet, to do more than indicate the future which is assuredly reserved for saccharine. It will be found that the statements herein made will, one and all, withstand the test of practice, for they are based upon experimental results which have been actually obtained. Its commercial success would now seem to be assured, and should this prove to be the case, there will be none to begrudge Dr. Fahlberg the richly-merited reward of his arduous labours and his brilliant discovery.

---

*Sole Agents for Great Britain, Spain, and Portugal:*

WILSON, SALAMON & Co.,

18, Billiter Street,

London, E.C.